SEASONAL DISTRIBUTION OF MAYFLIES (EPHEMEROPTERA) IN TWO PIEDMONT RIVERS IN VIRGINIA[1]

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ABSTRACT: The seasonal distribution of the mayflies in two piedmont rivers was studied from 1977 to 1978. Adult and nymphal data were integrated to elucidate seasonal trends. Fourteen species were encountered in sufficient numbers to determine their seasonal periodicity; 12 other species that occurred infrequently are listed. The fauna could be divided into three temporal components based on the time of their emergence: winter/early spring, spring, and summer/fall.

The distribution and seasonal pattern of mayflies of the eastern United States are not well known. Berner (1977) gave distributional records for many of the southeastern species of mayflies; however, he did not include the state of Virginia. To date the only study on distribution and seasonal occurrence of mayflies of Virginia has been Pugh (1956).

From 1977 to 1978 we conducted a detailed investigation of the downstream effects of impoundment on the life histories of two species of mayflies in Virginia (Kondatieff and Voshell 1980, 1981). This report presents notes on the distribution and seasonal patterns of other species of mayflies that we encountered during our studies.

Study Area

The North and South Anna Rivers (NAR and SAR, respectively) are tributaries of the York River Basin located in eastern Virginia (Fig. 1). Both rivers begin in the Piedmont Plateau Province and flow southeastwards over the Fall Line before joining to form the Pamunkey River in the Coastal Plain Province. The Fall Line is the boundary between the Piedmont Plateau and Coastal Plain Physiographic Provinces. Usually a succession of ledges result at this narrow zone because the granitic rocks pass below tide level. Most of the basin is forested (70%) or in cropland or pasture (22%), and only 2% is classified as urban (Virginia Division of Water Resources 1970). The NAR was impounded in 1972 to provide cooling water for a nuclear-powered electricity generating facility. Lake Anna is a mainstream impoundment with an area of 5261 ha; release is from the

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surface of the reservoir.

Two stations were established on each river at the Fall Line (Fig. 1). The study site on the NAR is approximately 32 km below Lake Anna. The elevation at the site is 20 m, with a gradient of 21.8 m/km, and the width is 73 m. At this point the river is a 5th order stream that drains approximately 1.14×10^5 ha. The substrate consists primarily of coarse pebble (32-64 mm), cobble (64-256 mm), and boulder (>256 mm). This site is characterized by several cascading falls and small islands producing auxillary side channels. The islands and shallow areas with slow current are covered with dense growths of *Justicia americana* (Linnaeus) (water-willow). Mine drainage previously affected the overall ecology of the river, but the impoundment of the NAR has alleviated the perturbation (Simmons and Voshell 1978).

The study site on the SAR was also established at the Fall Line. The elevation is 38 m, the gradient is 3.4 m/km, and the width is 100 m. At this point the SAR is also a 5th order stream, and its watershed is approximately 1.02×10^5 ha. The physical composition of the substrate is similar to the NAR, but the aquatic macrophyte *Podostemum ceratophyllum* (Michaux)

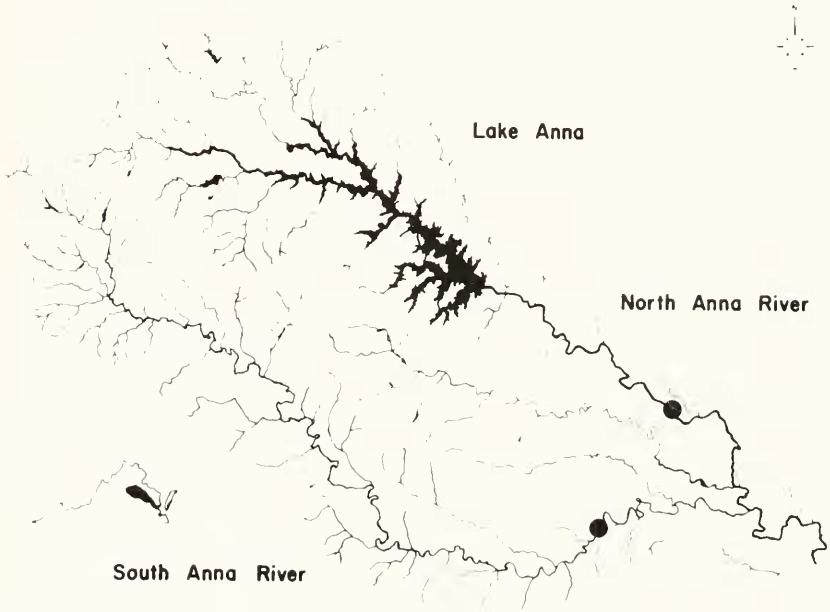


Fig. 1. Map of North and South Anna Rivers in Virginia, USA, indicating locations of sampling stations. (●).

(river weed) forms thick carpets on large rocks in fast water during summer months. Both rivers exhibit soft to medium hardness (12-35 ppm $CaCO_3$) and circum-neutral pH (5.90-8.05). Water temperatures range from 2-29° C. A complete description of the study area can be found in Flint et al. (1979) and Kondratieff and Voshell (1981).

Methods

Field studies were conducted from June 1977 to June 1978. Nymphs were collected in riffles with a Portable Invertebrate Box Sampler (PIBS) (Ellis Rutter Assoc., Douglassville, PA), D-frame dip net, and by hand. Samples were taken monthly in the winter (November to March) and every two weeks for the remainder of the year. Imagoes and subimagoes were collected from spring to autumn with portable black light traps and with lights (either black light or Coleman lantern) at white sheets of cloth. The collecting traps or lights were usually set up before dusk and operated for 1 to 2 hrs. Subimagoes were allowed to transform in ventilated plastic jars lined with wire screen. Mature nymphs of all species were collected, returned to the laboratory, and reared for positive association. Reliable specific identification is presently not possible for eastern *Pseudocloeon* and *Tricorythodes* species. For this reason, the nearest specific names are given.

Results and Discussion

South Anna River

Many of the species in the SAR were closely associated with the *Podostemum ceratophyllum*. The thick mats provide food and shelter for a mayfly community dominated by Ephemerellidae and Baetidae. The mayflies inhabiting *Podostemum* could be divided into three temporal components based on the time of their emergence: winter/early spring, spring, and summer/fall (Fig. 2). *Baetis amplus* was the sole example of the winter/early spring element, emerging as early as late February during warm periods. Apparently it had a univoltine life cycle in the SAR. Nymphs were absent in bottom samples from middle June to late November. Rapid growth occurred during the winter months.

Spring emerging species included *Drunella tuberculata, Ephemerella invaria, E. needhami,* and *Eurylophella versimilis.* All of these species were univoltine and exhibited short seasonal emergence periods. Subimagoes of *D. tuberculata* and *E. invaria* emerged in late morning (ca. 8:30 A.M. to 11:00 A.M.). Mating flights of both species occurred near dusk (ca. 7:00 P.M. - 9:30 P.M.). *Isonychia pictipes* was bivoltine at this site with one brood hatching from late March to middle May and the second from July to early October. Subimagoes emerged in late afternoon to early evening (ca. 6:00 P.M. - 7:30 P.M.). Nuptial flights were observed near

dusk (ca. 8:00 P.M. - 9:30 P.M.).

The summer/fall emerging component included the most abundant species and those with the longest seasonal emergence periods: *Baetis intercalaris, B. ephippiatus, Serratella deficiens, S. serratoides, Pseudocloeon* nr. *dubium,* and *Tricorytodes* nr. *allectus.* The two species of *Baetis* emerged from late morning to late afternoon (ca. 11:00 A.M. - 4:00 P.M.) throughout the summer months. The life cycles of both species were difficult to interpret from nymphal or emergence data. Nymphs were present in all stages throughout the warm months (Fig. 3). The life cycle of *Heterocloeon curiosum* was bivoltine (Figs. 2 and 4) and has been described in detail by Kondratieff and Voshell (1981). Other than *H. curiosum* and *B. intercalaris, E. serratoides* was the most abundant mayfly in the mats of river weed. Large hatches of this species were observed, with a peak in early July. Nymphs were present in bottom samples from October to middle August (Fig. 5). Nymphs of *S. deficiens* were present from February to November. Peak nympal density was observed in early October (Fig. 6). *T.* nr. *allectus* did not exhibit definite emergence modes. Small sporadic emergences occurred in early afternoon throughout the

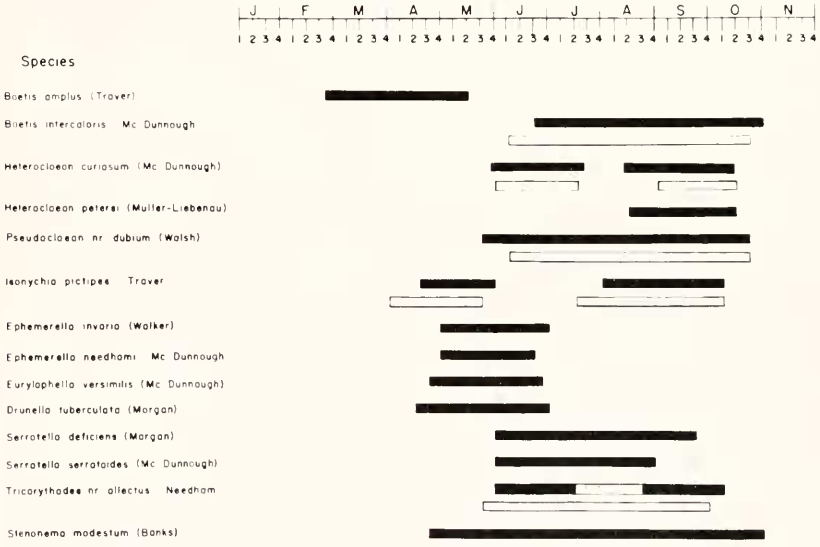


Fig. 2. Seasonal occurrence of imagoes from June 1977 to June 1978. Open bars = North Anna River; solid bars = South Anna River. Baetidae: *B. amplus, B. intercalaris, H. curiosum, H. petersi, P.* nr. *dubium;* Oligoneuriidae: *I. pictipes;* Ephemerellidae: *E. invaria, E. needhami, E. versimilis, D. tuberculata, S. deficiens, S. serratoides;* Tricorythidae: *T.* nr. *allectus;* Heptageniidae: *S. modestum.*

summer similar to what Macan (1958) called "driblets". *Heterocloeon petersi* emerged for a short period in late afternoon in the later summer and early fall. Nymphs of *H. petersi* were present in bottom samples from early summer (middle June) to late fall (October).

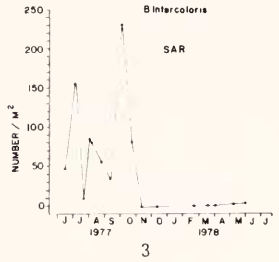
Other mayflies encountered at this site but collected too infrequently to ascertain emergence periodicity were *Stenacron interpunctatum* (Say), *Stenonema modestum* (Banks), *S. integrum* (McDunnough), *S. terminatum* (Walsh), *Heptagenia flavescens* (Walsh), *Leucrocuta aphrodite* (McDunnough), *Drunella lata* (Morgan), *Neoephemera youngi* Berner, *Caenis amica* Hagen, and *Hexagenia munda* Eaton. *Leptophlebia bradleyi* (Needham) also inhabited nearby marshes from which it emerged in early March.

North Anna River

The mayfly community in the NAR was dominated by members of the families Heptageniidae and Baetidae (Fig. 2). The Ephemerellidae were conspicuously absent, apparently because *Podostemum ceratophyllum* was not present to provide a suitable habitat. *Podostemum* probably once occurred in the NAR but was eliminated many years ago by acid and metal mine drainage. Lake Anna has significantly improved the quality of downstream water by acting as a sink for sediment and metals (Simmons and Voshell 1978), but *Podostemum* has not yet recolonized the NAR.

All mayflies occurring at this site were spring and summer/fall emerging species. The life history and ecology of *S. modestum* and *H. curiosum* have been reported by Kondratieff and Voshell (1980, 1981). The life cycle of *S. modestum* was probably bivoltine with "driblets" emerging throughout June and July. Peak nymphal densities in July, September, and October corresponded with emergence modes (Fig. 7). *H. curiosum* was bivoltine with the second brood emerging approximately 1 mo. later in the SAR (Fig. 8). The life cycles of *B. intercalaris, P.* nr. *dubium,* and *T.* nr. *allectus* were difficult to interpret. Possibly, *B. intercalaris* and *P.* nr. *dubium* were trivoltine and *T.* nr. *allectus* bivoltine at this site. Both *B. intercalaris* and *P.* nr. *dubium* emerged in late morning to early afternoon (ca. 11:00 A.M. - 4:00 P.M.) during the entire summer. Nuptial flights of both species occurred in late afternoon to early evening (ca. 2:00 P.M. - 7:00 P.M.). No emergence of *T.* nr. *allectus* was observed; however, a nuptial flight was observed in early morning (ca. 7:00 A.M. - 8:00 A.M.) in early August. *I. pictipes* had two emergence peaks at this site: one in late May/early June and the other in middle August. Nymphal densities are shown in Fig. 9.

Other mayflies occurring in the NAR but very rarely collected were *Neoephemera youngi* Berner, *Hexagenia munda* Eaton, *Ephemerella*



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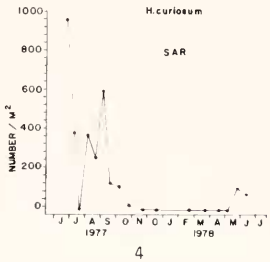

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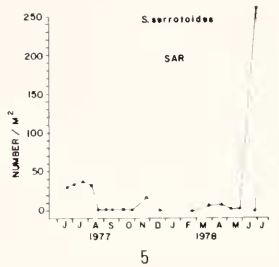

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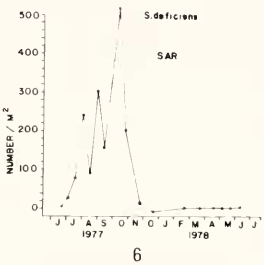

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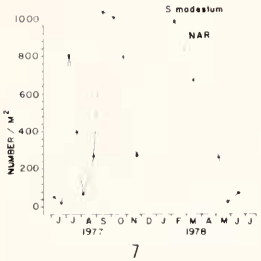

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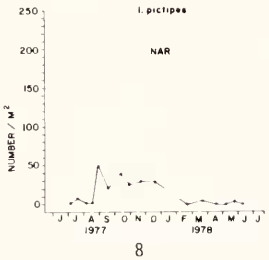

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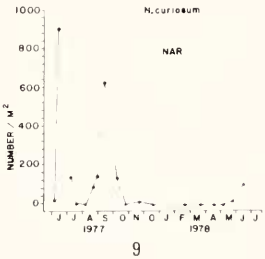

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Figs. 3 - 9. Seasonal densities of nymphs from June 1977 to June 1978 in the North Anna River (NAR) and South Anna River (SAR).

dorothea Needham, *Drunella tuberculata* Morgan, and *Heptagenia marginalis* Banks.

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